4 Renewable Energy

Renewable energy resources play a key role in Wisconsin's efforts to achieve the Governor's 25 x '25 goal, and to reduce dependence on imported fuels. Renewable resource use in Wisconsin is dominated by wood burning for heat and as biomass in electricity generation. In 2007, the residential and industrial sectors accounted for 63.1 percent and 29.6 percent of the wood burned, respectively. Wood energy use increased 11.4 percent in 2007. In the utility sector, Northern States Power uses wood for their electricity-generating fuel at the Bay Front and French Island generating plants.

Hydroelectric power currently ranks third as a renewable energy source in Wisconsin, behind wood and ethanol. Hydroelectric production is affected by annual rainfall, so page 66 shows state average rainfall figures to provide context for the relationship of rain to hydro production.

Biogas is produced from the state's landfills, wastewater treatment plants and manure digesters. Biomass is defined as paper by-products (e.g., paper pellets). Wood, while technically biomass, is represented separately because it comprises a major renewable resource in the state.

Ethanol, a renewable energy source primarily made from corn, is used as the oxygenate in reformulated gasoline sold in southeastern Wisconsin and as E10 and E85 throughout the state. In 2007, Wisconsin's use of ethanol in motor fuel increased 23.6 percent.

Note regarding changes in this publication:

The need to define renewable resources in the context of government programs, and current rules and laws has dictated the redesign of the methodology used to arrive at the figures for renewables. In addition, as technology improves and the use of renewable fuels increases, available data has improved allowing OEI to make a closer accounting of renewable resources as we strive to meet the Governor's 25 x '25 goal.

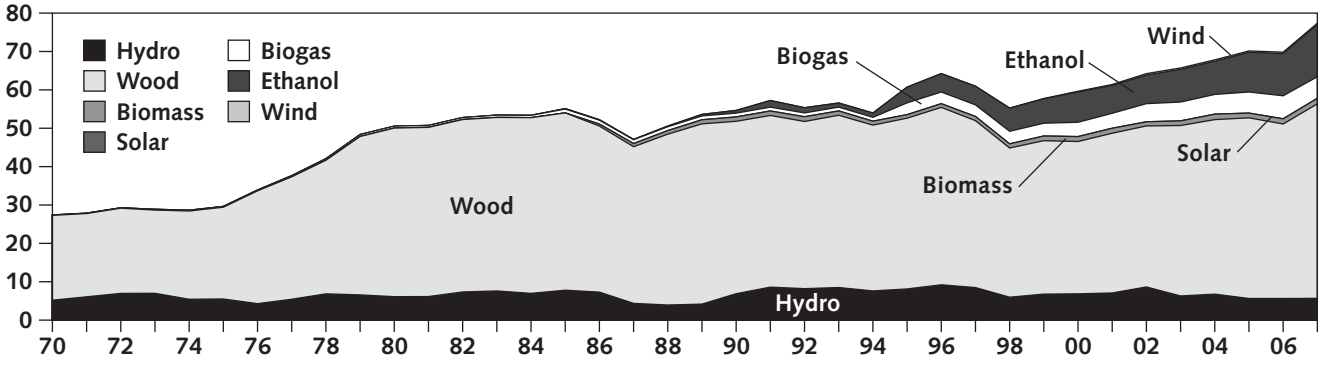
Two significant changes to this publication are:

- Waste derived from pre- and post-commercial waste, and refuse derived fuels (e.g., railroad ties, tires) are not included as sources of biomass.
- Passive solar systems (e.g., room lighting with sunlight) are not included. Solar data are limited to metered and installed solar applications for solar hot water and photovoltaic (electricity generation).

Wisconsin Renewable Energy Production, by Type of Fuel 1970-2007

(Trillions of Btu)

Renewable energy use in Wisconsin increased 10.8 percent in 2007. In 2007, ethanol use in the transportation sector increased 23.6 percent. Hydro generation includes electricity generation by Wisconsin utilities and dams owned by industrial users (e.g., paper mills). All the figures for solar energy, biomass and biogas have been historically revised to more accurately represent a revision to methodology and data sources. For example, this table does not include estimated passive solar, municipal solid waste or other refuse derived fuels (e.g., railroad ties, tires), as it has in previous publications.



Year	Hydro	Wood	Biomass	Solar	Biogas	Ethanol[a]	Wind	Total
1970	5.2	22.1	0.0	0.0	0.1	0.0	0.0	27.4
1975	5.5	23.9	0.0	0.0	0.2	0.0	0.0	29.6
1980	6.1	43.9	0.0	0.0	0.5	0.0	0.0	50.5
1985	7.8	46.2	0.0	0.0	1.0	0.1	0.0	55.1
1990	6.9	44.9	1.1	0.0	1.0	0.7	0.0	54.6
1995	8.1	44.5	0.9	0.0	3.1	4.1	0.0	60.7
2000	6.8	39.7	1.3	0.0	3.7	7.9	0.2	59.6
2001	7.1	41.6	1.3	0.0	3.9	7.3	0.2	61.4
2002	8.6	42.0	1.1	0.0	4.7	7.4	0.4	64.2
2003	6.3	44.4	1.2	0.00042	4.9	8.5	0.4	65.7
2004	6.8	45.5	1.4	0.00101	5.1	8.7	0.4	67.8
2005	5.6	47.1	1.2	0.00156	5.5	10.4	0.3	70.1
2006	5.6	45.5	1.3	0.00310	6.0	11.0	0.4	69.8
2007[p]	**5.7**	**50.7**	**1.5**	**0.00545**	**5.6**	**13.6**	**0.3**	**77.4**

[a] Ethanol is blended with a petroleum-based fuel to produce reformulated gasoline, E10 and E85.

[p] Preliminary estimates.

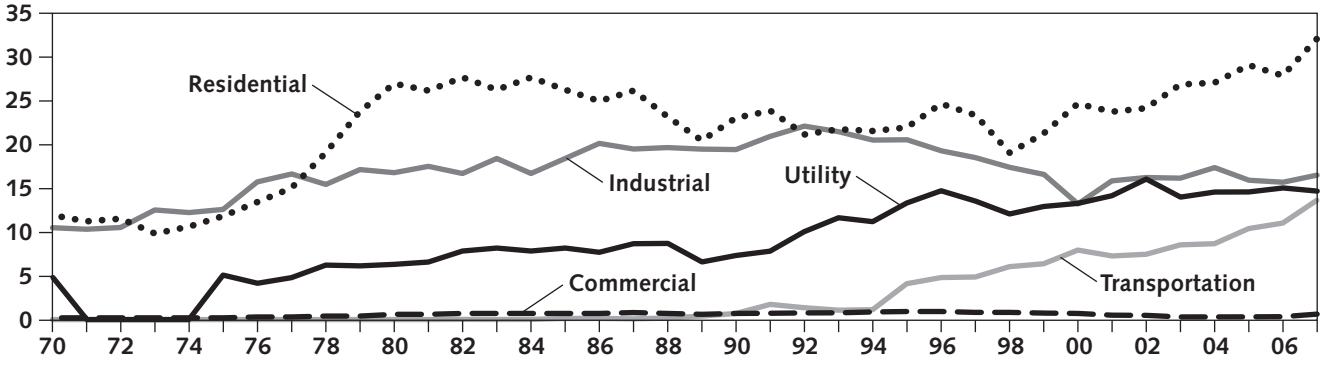
Source: Compiled from tables in this publication for Wisconsin wood and hydro and unpublished data from the Public Service Commission of Wisconsin and Focus on Energy (2007).

Wisconsin Renewable Energy Production, by Economic Sector 1970-2007

(Trillions of Btu)

Wisconsin's total end use energy increased by 14.4 percent. Wood –primarily in the residential sector—dominates renewable energy use, but hydroelectric, biogas and biomass (e.g., paper pellets) are also used. Transportation use of renewable energy consists of using ethanol in reformulated gasoline, E10 and E85.

The numbers in this table represent a historical revision to all renewables numbers to remove non-metered resources such as passive solar energy and resources not considered renewable under Wisconsin law (e.g., municipal solid waste and refuse derived fuel such as railroad ties and tires). This has an impact on all sectors when compared to previous versions of this publication.



Year	Residential	Commercial	Industrial	Electric Utility	Transportation	Total Resources	Total End Use
1970	11.9	0.2	10.5	4.8	0.0	27.4	22.6
1975	11.8	0.2	12.6	5.1	0.0	29.6	24.6
1980	26.9	0.6	16.7	6.3	0.0	50.5	44.2
1985	26.1	0.8	19.4	8.7	0.1	55.1	46.5
1990	21.1	0.8	22.1	10.0	0.7	54.6	44.6
1995	21.9	0.9	20.5	13.3	4.1	60.7	47.4
2000	24.6	0.7	13.2	13.2	7.9	59.6	46.4
2005	29.0	0.3	15.9	14.6	10.4	70.1	55.6
2006	27.8	0.3	15.7	15.0	11.0	69.8	54.8
2007P	**32.0**	**0.6**	**16.5**	**14.6**	**13.6**	**77.4**	**62.7**

P Preliminary estimates.

Source: Compiled from tables in this publication for Wisconsin wood and hydro, unpublished data from the Public Service Commission of Wisconsin and Focus on Energy (2006 - 2007), and telephone survey of landfills and wastewater biogas production facilities.

Wisconsin Wood Use, by Economic Sector 1970-2007

(Trillions of Btu and Percent of Total)

Wood energy use in Wisconsin increased by 11.4 percent in 2007, primarily due to cold winter weather. The residential wood use is estimated using a variety of factors including heating degree days, cost of other winter fuels and gross domestic product, the efficiency factor of wood, and the number of households in Wisconsin. In this table, Commercial is used in a broad context to include schools, hospitals, wholesalers and retailers, and construction.

Year	Residential[a]		Commercial		Industrial		Electric Utility		Total
1970	11.9	(53.8%)	0.2	(0.9%)	10.0	(45.2%)	0.0	(0.0%)	22.1
1975	11.8	(49.3)	0.2	(0.8)	11.9	(49.8)	0.0	(0.0)	23.9
1980	26.9	(61.2)	0.6	(1.4)	15.7	(35.7)	0.7	(1.7)	43.9
1985	26.1	(56.5)	0.8	(1.7)	17.6	(38.2)	1.7	(3.6)	46.2
1990	21.1	(47.0)	0.7	(1.6)	20.0	(44.6)	3.1	(6.9)	44.9
1995	21.9	(49.2)	0.6	(1.3)	18.5	(41.6)	3.5	(7.9)	44.5
2000	24.6	(62.0)	0.4	(1.0)	11.3	(28.4)	3.4	(8.6)	39.7
2001	23.7	(56.9)	0.3	(0.7)	14.2	(34.0)	3.5	(8.4)	41.6
2002	24.1	(57.4)	0.3	(0.7)	14.3	(34.1)	3.3	(7.8)	42.0
2003	26.8	(60.3)	0.2	(0.5)	14.3	(32.1)	3.2	(7.1)	44.4
2004	27.0	(59.4)	0.2	(0.4)	15.4	(33.9)	2.9	(6.3)	45.5
2005	29.0	(61.6)	0.2	(0.4)	14.9	(31.7)	3.0	(6.3)	47.1
2006	27.8	(61.1)	0.2	(0.4)	14.0	(30.8)	3.5	(7.7)	45.5
2007[p]	**32.0**	**(63.1)**	**0.2**	**(0.5)**	**15.0**	**(29.6)**	**3.4**	**(6.8)**	**50.7**

[a] Revised.

[p] Preliminary estimates.

Source: U.S. Department of Energy, Energy Information Administration, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981* (August 1983); Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2007); USDA Forest Service, *Residential Fuelwood Consumption and Production in Wisconsin* (1994); Wisconsin Department of Administration, Division of Energy, "Wisconsin Residential Wood Energy Model," unpublished (2007), and *Directory of Wisconsin Wood Burning Facilities* (1995).

Wisconsin Manufacturing Industry Use of Wood Fuel, by Industry Group, 1972-2007

(Thousands of Tons and Trillions of Btu[a])

The use of wood and wood products as fuel by Wisconsin industries is concentrated among businesses that use or produce a wood product. Lumber mills burn sawdust, bark and scrap wood as a boiler fuel and for kiln drying boards. Furniture and paper companies use scrap wood and wood byproducts for process steam, heating and generating electricity. Wood in Wisconsin is a renewable resource for heating as well as electricity generation.

Year	Lumber		Furniture		Paper & Allied		Other Manufacturing		Total	
	(Tons)	(Btu)	(Tons)	(Btu)	(Tons)	(Btu)	(Tons)	(Btu)	(Tons)	(Btu)
1972	391.2	4.43	13.2	0.15	508.5	4.88	16.1	0.18	929.0	10.50
1975	437.2	4.94	24.5	0.27	575.6	6.51	17.1	0.19	1,054.5	11.92
1980	447.5	5.06	56.9	0.64	872.8	9.86	12.0	0.13	1,389.2	15.70
1985	427.3	4.83	53.9	0.61	1,046.7	11.83	33.5	0.38	1,561.3	17.64
1990	490.9	5.55	64.0	0.72	1,186.5	13.41	30.0	0.34	1,771.4	20.02
1995	490.2	5.54	49.0	0.55	1,050.0	11.87	48.0	0.54	1,637.2	18.50
1996	481.0	5.42	45.0	0.51	951.0	10.75	45.0	0.51	1,522.0	17.19
1997	473.0	5.34	40.0	0.45	902.0	10.19	35.0	0.40	1,450.0	16.38
1998	459.0	5.19	35.0	0.40	853.0	9.64	25.0	0.28	1,372.0	15.51
1999	448.0	5.06	30.0	0.34	801.0	9.05	15.0	0.17	1,294.0	14.62
2000	433.5	4.90	20.1	0.23	534.5	6.04	8.0	0.09	996.1	11.26
2001	420.5	4.75	19.0	0.21	800.7	9.05	12.2	0.14	1,252.4	14.15
2002	415.2	4.69	17.2	0.19	823.4	9.30	10.4	0.12	1,266.2	14.30
2003	384.3	4.34	15.3	0.17	855.2	9.66	8.0	0.09	1,262.8	14.26
2004	434.7	4.91	13.5	0.15	905.3	10.23	10.2	0.12	1,363.7	15.41
2005	422.4	4.77	10.8	0.12	877.0	9.91	10.2	0.12	1,320.4	14.92
2006	357.1	4.04	7.6	0.09	856.6	9.68	16.2	0.18	1,237.5	13.99
2007	**361.3**	**4.08**	**7.5**	**0.08**	**938.9**	**10.61**	**19.3**	**0.22**	**1,327.0**	**15.00**

[a] Gross heating values of wood range from 8 MMBtu per ton to 17 MMBtu per ton, due in part to differences in moisture content. In this table, 11.3 MMBtu per ton is used, based on estimates of moisture content and type of wood used in Wisconsin.

Source: Estimates by the Wisconsin Office of Energy Independence, based on Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2007); Employment Research Associates, *Biomass Resources: Generating Jobs and Energy*, Technical Papers (January 1986); Department of Administration, Division of Energy, *Directory of Wisconsin Wood Burning Facilities* (1995).

Wisconsin Electric Utility Use of Wood Fuel 1970-2007

Wood energy used for electricity in Wisconsin increased in 2007 when Northern States Power (NSP) Company increased wood usage at its Bay Front plant. NSP began using wood fuel at Bay Front in 1976 and at its French Island facility in 1980. These are the only electric utility generation sites in Wisconsin using significant amounts of wood.

Year	Tons	Billions of Btu
1970-1975	0	0
1980	76,282	740
1985	155,717	1,666
1990	299,464	3,112
1995	327,201	3,506
2000	296,739	3,430
2001	301,580	3,484
2002	283,774	3,260
2003	267,446	3,154
2004	242,973	2,877
2005	253,638	2,961
2006	288,907	3,482
2007	**315,811**	**3,437**

Source: Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-1994); annual reports of various Wisconsin electric generating utilities (1995-2007).
http://psc.wi.gov/apps/annlreport/content/munilist.aspx

Wisconsin Electric Utility and Non-Utility Hydroelectric Generation[a], 1970-2007

(Millions of kWh)

Total Wisconsin electric utility hydroelectric production increased 4.4 percent from 2006 to 2007. With the exception of the numbers for Michigan, 2007 data in this table are preliminary estimates based on available electric production data and previous year's data.

Year	Wisconsin Owned Utility Plant Location		Total Utility	Wisconsin Non-Utility[b]	Total Wisconsin	Total Wisconsin Precipitation (inches per year)
	Wisconsin	Michigan				
1970	1,413.2	448.1	1,861.3	110.0	1,523.2	32.0
1975	1,482.9	450.3	1,933.2	129.4	1,612.3	32.4
1980	1,628.3	488.9	2,117.2	160.4	1,788.7	32.5
1985	2,046.3	543.6	2,589.9	235.9	2,282.2	37.0
1990[c,r]	1,791.0	340.2	1,865.2	223.4	2,014.4	36.2
1995	2,097.1	440.1	2,537.2	281.4	2,378.5	32.9
2000	1,749.4	369.6	2,119.0	241.4	1,990.8	34.8
2001	1,887.6	383.3	2,270.9	168.6	2,056.2	35.5
2002	2,282.9	485.8	2,768.7	232.1	2,515.0	35.2
2003	1,623.4	373.4	1,996.8	219.9	1,843.3	28.4
2004	1,748.4	401.0	2,149.4	232.3	1,980.7	35.3
2005[r]	1,595.7	338.6	1,934.3	51.7	1,647.4	29.2
2006[r]	1,504.6	326.3	1,830.9	142.2	1,646.8	30.7
2007[P]	**1,570.4**	**272.6**	**1,843.0**	**85.0**	**1,655.4**	**34.0**

[a] Including Wisconsin power cooperatives.

[b] Estimated.

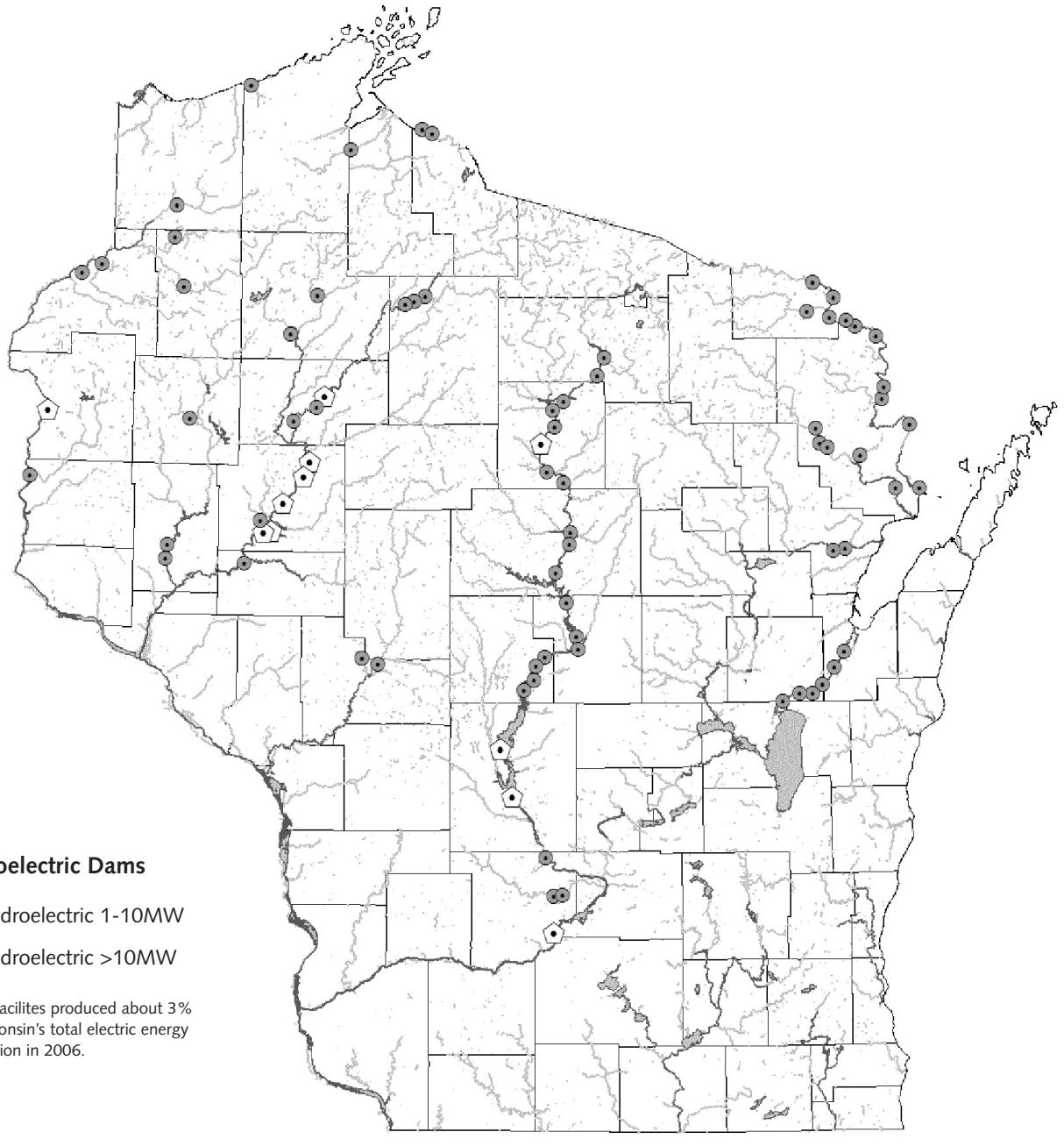
[c] Beginning in 1990, the U.S. DOE data source has been used. Starting in 2005, EIA data are revised using unpublished electric production data from the Public Service Commission of Wisconsin.

[P] Preliminary estimates.

[r] Revised.

Source: Public Service Commission of Wisconsin, Accounts and Finance Division, *Generating Plants Operated by Wisconsin Electric Utilities*, Bulletin #46 (1971-1994); U.S. Department of Agriculture, Rural Electrification Administration, *Annual Statistical Report*, REA Bulletin 1-1 (1971-1994); Wisconsin Department of Administration, Division of Energy, Wisconsin Hydroelectric Generation Model, unpublished (1994); National Oceanic and Atmospheric Administration, *Monthly State Heating Degree Days, Historical Climatology Series 5-1* (April 2004); U.S. Department of Energy, Energy Information Administration, *Electric Power Monthly* [DOE/EIA-0226 (2007/03)] (March 2007), http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html; Public Service Commission of Wisconsin, unpublished electrical production data (2005-2007).

Electric Utility Hydroelectric Sites in Wisconsin 2007



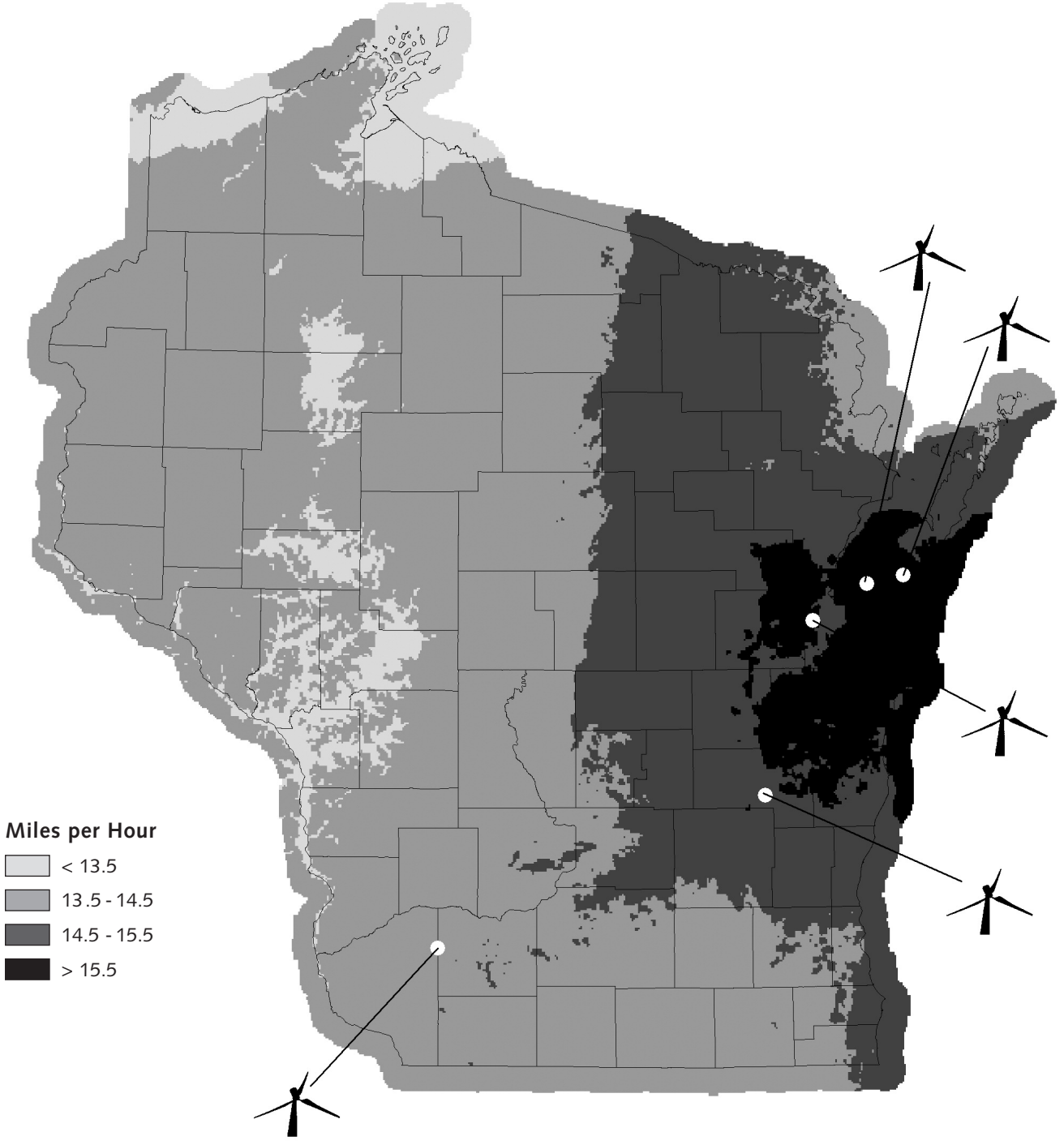
Hydroelectric Dams

- Hydroelectric 1-10MW
- Hydroelectric >10MW

Hydro facilites produced about 3% of Wisconsin's total electric energy production in 2006.

Source: Dams > 10MW Public Service Commission of Wisconsin – 2008; Dams 1-10MW Department of Administration.

Estimated Wisconsin Wind Energy Potential (at 60 Meters) and Wind Farm Locations, 2007



Source: Wisconsin Office of Energy Independence. Based on WindMap model and data collected by the Wisconsin Wind Interest Group (2001).

Wisconsin Renewable Energy Electricity Generated and Purchased, 1990-2007

(Millions of kWh)

In 2007, Wisconsin's electric utilities increased their sales of electricity generated from renewable energy sources by .6 percent. The primary renewable energy source used was hydropower, which increased 0.5 percent.

These figures have been revised from previous versions of this publication to remove resources that are not considered renewable under Wisconsin law (e.g., municipal solid waste or refuse derived fuels).

Year	Hydro	Wood	Biomass	Biogas	Wind	Total[a]
1990	2,014.4	196.9	68.1	0.0	0.0	2,279.5
1995	2,378.5	221.9	54.2	110.1	0.0	2,764.7
2000	1,990.8	217.1	78.3	197.2	46.6	2,530.0
2001	2,056.2	220.5	83.2	203.3	70.2	2,633.3
2002	2,515.0	206.3	70.8	214.3	111.1	3,117.5
2003	1,843.3	199.6	79.6	280.5	104.0	2,507.0
2004	1,980.7	182.1	98.3	317.5	105.3	2,683.9
2005[r]	1,647.4	187.4	51.5	263.0	93.5	2,242.8
2006[r]	1,646.8	220.4	156.1	404.0	102.7	2,530.0
2007[p]	**1,655.4**	**217.5**	**156.1**	**413.8**	**101.2**	**2,544.0**

[a] Wisconsin utilities generate a small amount of electricity—about 0.02 million kilowatt-hours annually—with solar photovoltaic systems.

[p] Preliminary estimates.

[r] Revised.

Source: Other renewable energy tables in this publication, unpublished data from the Public Service Commission of Wisconsin, Focus on Energy (2007), and telephone surveys of landfill and wastewater treatment biogas production facilities.